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ARCO NORTH ALEUTIAN SHELF COST NO. 1

JOB #05820107

FORAMINIFERA REPORT

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Alaska

Interpreted by:

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January 24, 1983

ARCO Exploration Company
P.O. Box 360
Anchorage, Alaska 99510

ATTENTION: Mr. David Hite

SUBJECT: Foraminiferal Analysis, ARCO North Aleutian Shelf COST No. 1, Bering Sea, Alaska

The attached report details our interpretation of the Foraminifera occurrences from the ARCO North Aleutian Shelf COST No. 1 from the Bering Sea.

Work on this project was done by BioStratigraphics in San Diego. A total of 524 ditch, 153 sidewall core, and 145 conventional core samples from 1318 to 17,150 feet T.D. were examined.

If you have any questions on any of the enclosed material give us a call.

Sincerely,

Richard S. Boettcher

Richard S. Boettcher
Biostratigrapher Consultant

A. D. Warren
Senior Biostratigrapher
Manager

RSB:ADW/jam

CONTENTS

SUMMARY

Foraminifera in the North Aleutian Shelf COST No. 1 generally are quite sparse. The only exception to this is the interval 1380 and 2310 feet, which is dated as late Pliocene. The section from 2310 to 3900 feet is essentially barren of Foraminifera and is questionably dated as late Miocene to early Pliocene.

A short Miocene undifferentiated interval occurs between 3900 and 4080 feet, and a late? Oligocene to middle? Miocene section is present from 4080 to 5130 feet. Oligocene to early Miocene strata were penetrated between 5130 and 8160 feet.

An essentially unfossiliferous section from 8160 to 9577 feet, is, by superposition, late Eocene to early Miocene in age. The interval between 9577 and 10,590 feet represents late Eocene to early Oligocene deposition. The section below 10,590 feet to T.D. at 17,150 feet is barren of indigenous Foraminifera and can only be dated as indeterminate.

INTRODUCTION

Scope

Examination of 524 ditch samples, 153 sidewall core samples, and 145 conventional core samples provides the basis for this report. Sample coverage is from 1318 to 17,150 feet T.D.

Procedures

We used our standard techniques to process the material. Each sample was boiled in Quaternary-O and washed over 20 and 200 mesh screens. Each ditch sample normally represents 30 feet of drilled section, although there are occasional exceptions.

Two picked slides were prepared for each ditch sample. Only one slide was picked for the sidewall and conventional core samples.

The frequency symbols used in this study and their numerical equivalents are: ? = questionable identification (no absolute numerical value, but usually one or two specimens); V = very rare (1); R = rare (2-10); F = frequent (11-32); C = common (33-100); and A = abundant (100+).

Relatively little is known about the foraminiferal biostratigraphy of the Bering Sea. The North Aleutian Shelf COST No. 1 is the first offshore well drilled relatively close to the northern coast of the Alaska Peninsula.

Since planktonic species are absent in the North Aleutian Shelf COST No. 1, our age interpretations are based largely on studies of benthic Foraminifera from other northern Pacific regions. Possibly the most applicable of these to the Bering Sea is the study of Voloshinova, et al., (1970) of the Foraminifera from Sakhalin Island. Very few of the published species occurrences from the Alaska Peninsula (Rothwell, 1965) occur in the North Aleutian Shelf COST No. 1.

In addition to the above, our conclusions reflect somewhat the results of our previous studies of South Alaska sections. As more and more data are accumulated on the foraminiferal biostratigraphy of the Bering Sea area, we would anticipate refinements in the age and correlations of various sections.

Paleoenvironmental interpretations generally follow the models of Ingle (1980). However, we tend to modify certain species depth ranges along the lines of Bergen and O'Neil (1979) and Echols and Armentrout (1980).

Various workers have assigned depth ranges to the marine environmental zones that have come into wide use in paleoenvironmental studies. Since depth assignments vary somewhat from author to author, it is difficult to arrive at approximate depth values that are consistent with all published data.

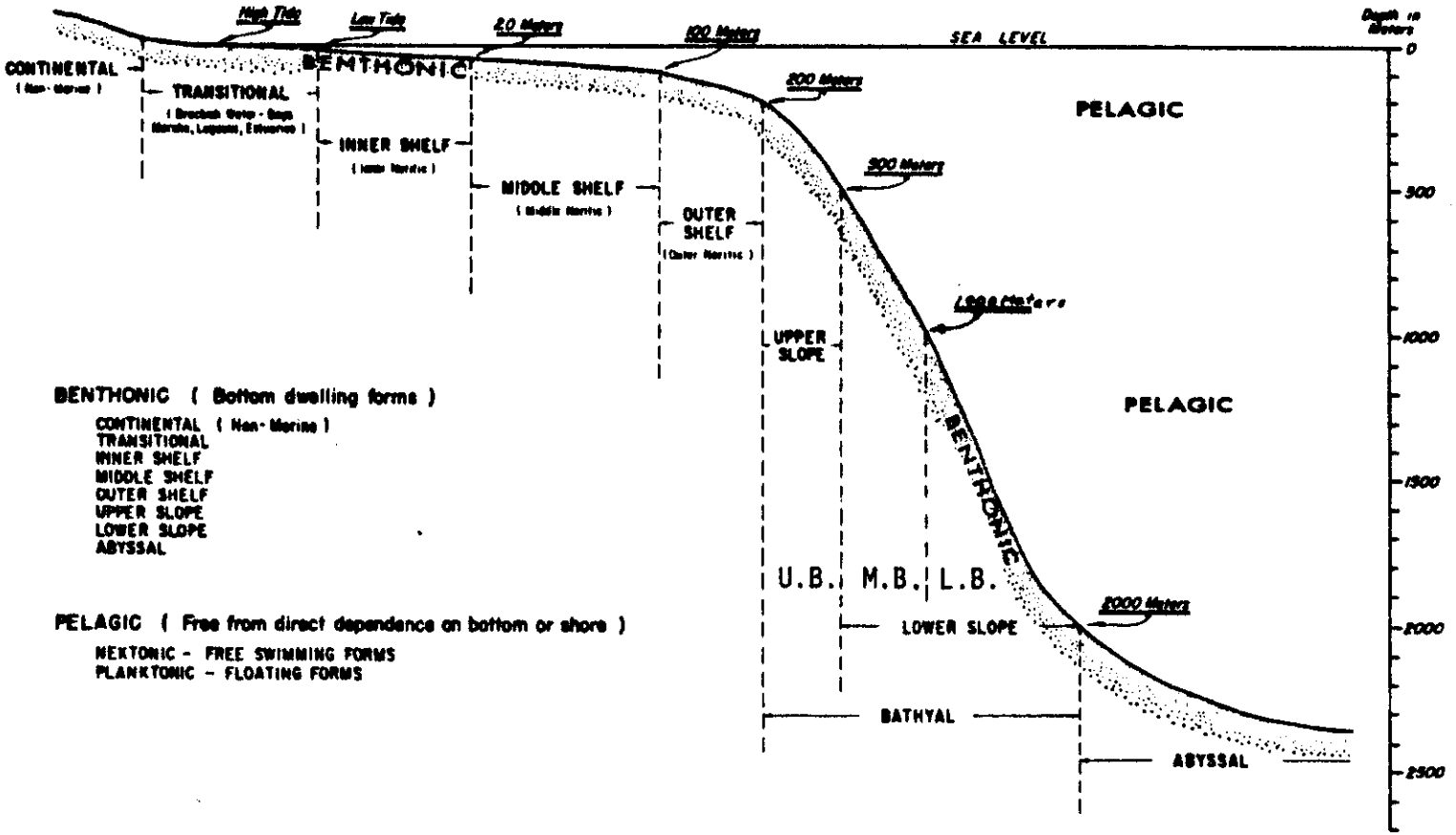
In order to be consistent in all our reports, we have settled on approximate depth values to be used in our paleoenvironmental and paleobathymetric interpretations (Text-Figure 1).

Paleobathymetric terms used here are:

	Inferred Water Depth Meters	Feet
Nonmarine (Continental Fluvial, etc.)	-	(-)
Transitonal (Brackish Bays, Lagoons, etc.)	0-5m.	(0-15 ft.)
Inner Neritic (Inner Shelf)	0-20m.	(0-60 ft.)
Middle Neritic (Middle Shelf)	20-100m.	(60-300 ft.)
Outer Neritic (Outer Shelf)	100-200m.	(300-600 ft.)
Upper Bathyal (Upper Slope)	200-500m.	(600-1500 ft.)
Middle Bathyal (Middle Slope)	500-1000m.	(1500-3000 ft.)
Lower Bathyal (Lower Slope)	1000-2000m.	(3000-6000 ft.)
Abyssal	Over 2000m.	(over 6000 ft.)

TEXT-FIGURE 1.

CLASSIFICATION OF MARINE ENVIRONMENTS



Modified after Tipsword, Setzer and Smith, 1966, GCAGS Transactions, vol. XVI, p. 122.

Format

The next section of this report contains a discussion of the major age subdivisions. Following this is a presentation of our conclusions. The final section of this report is the appendix, which lists the faunas for each conventional core sample.

In addition to the data in the body of the text, we have enclosed faunal range charts and a foraminiferal summary log in a pocket at the back of the report.

The foraminiferal summary log (Figure F-1) lists the age and paleoenvironment, plus the key fossils and lithologies, for each interval. In addition, we have also plotted the faunal diversities, i. e., the number of species noted.

In general, diversity maxima and minima should correspond to transgressions and regressions, and should also represent correlatable events among various wells. As such, they can provide an additional tool to the understanding of the geologic history of an area.

There are three faunal range charts for both the ditch samples (Figures F-2, F-3, and F-4) and the sidewall core samples (Figure F-5, F-6, and F-7). There has

been no attempt to subjectively stop recording species occurrences, even if we feel that these occurrences may be the result of slumping. Basically, the range charts reflect all the fossil occurrences in the sample.

BIOSTRATIGRAPHIC RESULTS

In this section we present all pertinent age and environmental data, from youngest to oldest. Within each age subdivision we discuss, in generalized terms, the faunal and lithologic character of the section. Finally, we list taxa that may have stratigraphic and/or paleoenvironmental significance.

In this section, as well as on the summary log and on the range charts, the interpreted ages are based on data from all material, *i. e.*, ditch samples, sidewall core samples, and conventional core samples.

1380-2310'

Age. The faunas in this part of the section appear similar to those dated as late Pliocene in other parts of the Bering Sea. It is difficult, however, to positively exclude an early Pleistocene age. Siliceous microfossils suggest that the upper part of this interval is, in fact, early Pleistocene.

1380-2310' (Continued)

Environment. The section between 1380 and 1560 feet represents middle to outer neritic deposition. From 1560 to 1740 feet an outer neritic category seems most likely. Below 1740 feet, we again place the section in the middle to outer neritic. The very sparse faunas below 2130 feet are arbitarily still called middle to outer neritic.

Remarks. Faunas are generally fairly common down to about 1740 feet, and then gradually decline below this depth.

Some of the species noted in this interval include Angulogerina angulosa, Cassidulina californica, C. cf. laticamerata, Elphidium clavatum, Nonion labradoricum, Uvigerina juncea and Vaginulina spp. Shells and echinoids are rare to common, while fish remains, diatoms and ostracods occur in lesser numbers.

The lithologies primarily are light gray and light brown sandy mudstones. The lithology usually breaks down during processing, leaving a variety of rounded rock fragments and finer grained sand. Glauconite occurs below about 2200 feet. Pyrite is generally rare to frequent in this interval.

2310-3900'

Age. We interpret this part of the section to be late Miocene to early Pliocene in age, even though it is essentially barren of Foraminifera. We have noticed in other wells from the Bering Sea a similar barren zone, which is consistently dated as late Miocene to early Pliocene on the basis of siliceous fossils.

2310-3900' (Continued)

Environment. The interval from 2310 to 3420 feet is called marine, based on the fairly abundant siliceous fossils. Below 3420 feet fossils are essentially lacking, and we place this part of the section in an indeterminate category.

Remarks. Foraminifera are essentially lacking in this interval. Specimens noted on the range charts are probably the result of slump from uphole. Siliceous remains, primarily diatoms, are quite common above 3420 feet, and decrease below this depth. Echinoids are also fairly common between about 2790 and 2940 feet.

Lithologies continue to be light gray to brown sandy mudstones. Down to 2910 feet glauconite is rare to common, and pyrite normally is rare to common throughout this entire interval. Plant fragments/lignite occur in most samples in this part of the section, and generally are quite abundant below 2610 feet.

3900-4080'

Age. The relatively sparse, shallow water forms in this interval are difficult to date. We call them Miocene, and it may be that they are the shallow water equivalents of early to middle Miocene faunules noted in deeper water Bering Sea faunules.

Environment. Inner neritic species typify this part of the well.

Remarks. Faunas are quite sparse in this part of the section and some samples are barren of Foraminifera.

3900-4080' (Continued)

Some of the species recorded include Elphidium cf. bartletti, E. clavatum, and Elphidiella cf. hannai. Shells are usually quite common in this interval, and echinoids are rare.

Light brown to gray micaceous mudstones are the most common lithology. Pyrite is rare to frequent and plant fragments/lignite are rare to common.

4080-5130'

Age. This interval is also very difficult to date. Porosorotalia cf. clarki at 4080 feet, is a species recorded from the Miocene of Sakhalin Island (Voloshinova, et al., (1970). Some of our previous work, however, suggests this species can also occur in the later? part of the Oligocene. Consequently, we spread the age of this part of the well from late? Oligocene to middle? Miocene.

Environment. Paleodepths at 4080 feet are inner to middle neritic, shoaling to probable inner neritic below 4410 feet.

Remarks. Faunas generally are fairly sparse in this interval, and many samples are barren of Foraminifera.

Some forms noted include Elphidiella cf. hannai, Elphidium clavatum, E. cf. sibiricum, Porosorotalia cf. clarki, and Sigmomorphina cf. pseudoschencki (single specimen at 4380 feet). Shells are rare to common in this part of the section and echinoides are sporadically rare to frequent. Very rare to rare diatoms occur sporadically and may be slumped from uphole.

4080-5130' (Continued)

Medium to light brown to gray sandy mudstones, siltstone, and occasional sandstones are the dominate lithologies. Dolomite does occur, especially below 4380 feet. Glauconite is generally frequent to common, and pyrite is sporadically rare to frequent.

5130-8160'

Age.

Rotalia cf. beccarii at 5130 feet is our marker for Oligocene to early Miocene strata. We recognize, however, that the data of Voloshinova, et al., (1970) suggest this species does not exist below the Miocene on Sakhalin Island.

In addition, Loeblich and Tappan (1964) indicate that the genus Ammonia (= Rotalia cf. beccarii of this report) did not evolve until the Miocene. We have, however, seen this species in material that is dated as Oligocene by nannofossils. One of the problems is that Rotalia cf. beccarii occurs only in shallow water, often in marsh/lagoon environments. These environments are not very conducive to nannoplankton development, so it is difficult to find good planktonic control associated with R. cf. beccarii. Consequently, we believe that the total geologic range of this species may not be fully documented, and that it may well extend down into the Oligocene.

There are very few species present between 6120 and 7900 feet. "Caucasina" sp. in the sidewall core at 7900 feet, in conjunction with Rotalia cf. beccarii in the ditch sample at 7980 feet, suggest that this interval is also Oligocene to early Miocene in age, although it may be slightly older than the faunule between 5130 and 6120 feet.

5130-8160' (Continued)

Caucasina spp. are often considered Eocene to possibly Oligocene indicators in the North Pacific (Serova, 1976). There is some question whether the "Caucasina" sp. present at 7900 feet in this well can be referred to any of the species figured by Serova. In fact, it is not 100 percent certain that the specimens should be referred to Caucasina at all. Possibly another genus (Buliminoides?) might be more applicable. Pending resolution of some of these problems, we tentatively refer to this entire interval as Oligocene to early Miocene in age.

Environment. The interval from 5130 to 5460 feet is best referred to an inner neritic environment. From 5460 to 5820 feet the faunas suggest middle neritic depths, followed by inner to middle neritic down to 6120 feet. A predominantly nonmarine setting is the paleoenvironment between 6120 and 7900 feet, although there possibly could be some minor episodes of very shallow marine deposition.

The paleoenvironment between 7900 and 8160 feet is marginal marine to inner neritic. However, the presence of coal in some samples (including core samples) suggest short periods of possible nonmarine deposition.

Remarks. Faunas are reasonably good from 5130 to 5550 feet, and then decline. Some species noted are Buccella spp., Elphidiella cf. hannai, Elphidium cf. sibiricum, Cassidulina cf. crassipunctata, Porosorotalia cf. clarki (limbate sutures, single specimen at 5310 feet), and Rotalia cf. beccarii. Shells are rare to frequent, and diatoms (pyritized) are also rare to frequent both in the ditch and core samples.

5130-8160' (Continued)

The interval from 6120 to 7900 feet is barren of Foraminifera. Shells continue sporadically rare to frequent down to 7020 feet, then are virtually absent.

A slightly different fauna from that noted above occurs between 7900 feet (sidewall core) and 8160 feet. Species present include "Caucasina" sp., Elphidiella hannai?, Elphidium cf. sibiricum, E. sp., and Rotalia cf. beccarii. Shells are rare to frequent and diatoms (pyritized) rare to common.

Lithologies are mostly brown to gray carbonaceous mudstones, plus gray to tan to white sandstones. White tuffaceous sandstones become increasingly common below about 7000 feet. Pyrite is sporadically rare to common throughout this interval. Glauconite is frequent to common down to 5940 feet and then decreases. Lignite/coal is rare to common throughout the intire interval.

The sidewall core at 5512 feet deserves a special comment. Several species are present in this sample that have not been noted previously in any Bering Sea samples, and/or their preservation appears to be different from other specimens in the sample. These species, flagged by an asterisk on the sidewall core chart, are Bolivina advena?, Buccella tenerrima, Elphidium sp., Nonion sp., and Nonionella digitata. These anomalous appearing forms may have been introduced into the sample somewhere along the sample collecting/processing line.

8160-9577'

Age. This essentially unfossiliferous zone cannot be precisely dated. By superposition it is probably late Eocene to early Miocene. Diatom data suggest the possibility it is Oligocene in age.

Environment. The continuous and fairly common occurrences of coal coupled with the absence of Foraminifera, suggest this interval is nonmarine. The occurrence of diatoms, however, (8461 feet) and fish remains (8686 feet) indicates that there probably are very limited intervals of shallow marine incursions.

Remarks. As indicated above, Foraminifera are absent from this part of the well. Diatoms and fish remains each occur in a single sidewall core sample. Shells are very rare and sporadic, especially near the top of this interval.

Lithologies are brown to gray to white carbonaceous shales, mudstones, and sandstones. Some light gray to white tuffaceous sandstones also occur. Pyrite is sporadically rare to frequent, and coal is rare to common.

9577-10,590'

Age. A new faunule starting at 9577 feet and continuing at least to 10,230 feet, and possibly to 10,590 feet, is probably late Eocene to early Oligocene in age. The species below 9945.6 feet especially are similar to those noted in other south Alaska sections, and which have been consistently dated by palynology and nannoplankton as late Eocene to possibly as young as early Oligocene.

9577-10,590' (Continued)

Environment. The section between 9577 and 10,020 feet represents inner to middle neritic deposition, deepening at 10,020 feet to outer neritic. Inner to middle neritic conditions are again indicated for the interval between 10,110 and 10,230 feet. The section from 10,230 to 10,590 feet probably fluctuated between nonmarine to shallow marine.

Remarks. Faunas are rather sparse and sporadic down to 10,020 feet, increase down to about 10,200 feet, and then are very rare and sporadic below this. Some of the forms recorded include Cribrononion aff. roemeri, Elphidiella cf. hannai, Elphidium sp., Globobulimina affinis, Haplophragmoides sp., Nonion (Melonis) sp. (single specimen at 10,050 feet) and Pseudoglandulina inflata. Shells are rare to common in the entire interval, while rare echinoids, ostracods, and diatoms (pyritized) occur sporadically between about 10,050 and 10,200 feet.

Lithologies at the top of this interval are brown to gray shales and siltstones, and lighter colored sandstones. Pyrite is rare to frequent throughout this interval, while glauconite is rare to common below 10,260 feet. Coal is rare and sporadic at the top of this part of the section, and becomes frequent to common below about 10,410 feet.

10,590-17,150' T.D.

Age. No indigenous Foraminifera are present in this interval. Consequently, no age dates are possible.

10,590-17,150' T.D. (Continued)

Environment. We interpret this part of the well to be mostly nonmarine in origin. This is based on the lack of Foraminifera, general lack of consistent shell material, plus the presence of coal. The latter is especially prevalent from 10,590 to about 15,090 feet, and from 16,050 to T.D. at 17,150 feet. It is possible that there may be some very restricted intervals of shallow marine deposition. Rare shell material between 10,590 and 10,770 feet, plus some questionable shelly material at about 16,000 feet could suggest very shallow marine conditions.

Remarks. Lithologies between 10,590 and about 15,630 feet generally are white to gray to brown shales and siltstones, plus white tuffaceous sandstones, often very carbonaceous. Below about 15,630 feet medium to dark gray to brown shales and siltstones predominate. Volcanic debris is present at 16,680 feet and rpaidly diminishes.

CONCLUSIONS

The following points summarize the major findings of this study:

1) 1380-2310'

Age: Late Pliocene
Env: Middle to Outer Neritic (1380-1560')
Outer Neritic (1560-1740')
Middle to Outer Neritic (1740-2310')

2) 2310-3900'

Age: Possible Late Miocene to Early Pliocene
Env: Marine (2310-3420')
Indeterminate (3420-3900')

3) 3900-4080'

Age: Miocene Undifferentiated
Env: Inner Neritic

4) 4080-5130'

Age: Late? Oligocene to Middle? Miocene
Env: Inner to Middle Neritic (4080-4410')
Probable Inner Neritic (4410-5130')

5) 5130-8160'

Age: Oligocene to Early Miocene
Env: Inner Neritic (5130-5460')
Middle Neritic (5460-5820')
Inner to Middle Neritic (5820-6120')
Mostly Nonmarine (6120-7900')
Marginal Marine to Inner Neritic (7900-8160')

6) 8160-9577'

Age: Late Eocene to Early Miocene
Env: Mostly Nonmarine

7) 9577-10,590'

Age: Probable Late Eocene to Early Oligocene
Env: Inner to Middle Neritic (9577-10,020')
Outer Neritic (10,020-10,110')
Inner to Middle Neritic (10,110-10,230')
Nonmarine to Shallow Marine (10,230-10,590')

8) 10,590-17,150' T.D.

Age: Indeterminate
Env: Mostly Nonmarine

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Appendix A

Analysis of Cores for

Foraminifera

Core 1 @ 3392.8'

Fauna. Barren of Foraminifera. Diatoms (V).

Core 2 @ 4195.2'

Fauna. Barren of Foraminifera. Shells (R).

Core 2 @ 4198.2'

Fauna. Barren of Foraminifera. Shells (R), Glauconite (R).

Core 2 @ 4199.3'

Fauna. Barren of Foraminifera. Shells (F), Glauconite (R).

Core 2 @ 4199.4'

Fauna. Barren of Foraminifera. Shells (R), Glauconite (F).

Core 3 @ 5228.9'

Fauna. Unfossiliferous.

Core 3 @ 5229.4'

Fauna. Unfossiliferous. Pyrite (R).

Core 3 @ 5230.3'

Fauna. Unfossiliferous.

Core 3 @ 5231.5'

Fauna. Unfossiliferous.

Core 3 @ 5235.2'

Fauna. Unfossiliferous. Pyrite (F).

Core 3 @ 5235.7'

Fauna. Unfossiliferous.

Core 3 @ 5238.3'

Fauna. Unfossiliferous. Glauconite (C).

Core 3 @ 5241.0'

Fauna. Unfossiliferous. Glauconite (F).

Core 3 @ 5242.1'

Fauna. Unfossiliferous. Glauconite (F).

Core 3 @ 5245.1'

Fauna. Unfossiliferous. Coal (F).

Core 4 @ 5971.5'

Fauna. Barren of Foraminifera. Shells (F).

Core 4 @ 5972.6'

Fauna. Barren of Foraminifera. Shells (R).

Core 4 @ 5974.3'

Fauna. Barren of Foraminifera. Shells (R).

Core 4 @ 5976.8'

Fauna. Barren of Foraminifera. Echinoids (V), Shells (F).

Core 4 @ 5979.9'

Fauna. Barren of Foraminifera. Echinoids (R), Shells (R).

Core 4 @ 5982.4'

Fauna. Barren of Foraminifera. Echinoids (R), Shells (F), Glauconite (R).

Core 4 @ 5985.6'

Fauna. Barren of Foraminifera. Shells (R), Glauconite (R).

Core 4 @ 5987.7'

Fauna. Cassidulina cf. crassipunctata (V), Elphidiella hannai (R), Shells (R), Glauconite (F).

Core 4 @ 5991.6'

Fauna. Barren of Foraminifera. Shells (R), Glauconite (C).

Core 4 @ 5995.5'

Fauna. Barren of Foraminifera. Shells (R), Glauconite (C).

Core 4 @ 6666.4'

Fauna. Unfossiliferous.

Core 5 @ 6667.1'

Fauna. Unfossiliferous.

Core 6 @ 8047.1'

Fauna. Unfossiliferous. Pyrite (R), Coal (F).

Core 7 @ 8056.3'

Fauna. Unfossiliferous. Coal (R).

Core 7 @ 8060.4'

Fauna. Unfossiliferous. Coal (C).

Core 7 @ 8063.4'

Fauna. Unfossiliferous. Coal (C).

Core 7 @ 8065.8'

Fauna. Unfossiliferous. Coal (R).

Core 7 @ 8066.8'

Fauna. Barren of Foraminifera. Diatoms (R).

Core 7 @ 8069.9'

Fauna. Unfossiliferous. Pyrite (R).

Core 7 @ 8073.9'

Fauna. Barren of Foraminifera. Diatoms (C), Coal (F).

Core 7 @ 8077.7'

Fauna. Unfossiliferous.

Core 7 @ 8079.1'

Fauna. Unfossiliferous. Coal (R).

Core 7 @ 8080.7'

Fauna. Unfossiliferous.

Core 7 @ 8083.8'

Fauna. Barren of Foraminifera. Diatoms (F), Pyrite (R), Coal (R).

Core 7 @ 8084.5'

Fauna. Barren of Foraminifera. Diatoms (V), Coal (R).

Core 7 @ 8087.9'

Fauna. Unfossiliferous. Coal (F).

Core 7 @ 8091.8'

Fauna. Unfossiliferous. Coal (C).

Core 7 @ 8092.5'

Fauna. Unfossiliferous. Coal (C).

Core 8 @ 8632.4'

Fauna. Unfossiliferous. Pyrite (R), Coal (F).

Core 8 @ 8636.2'

Fauna. Unfossiliferous. Pyrite (R), Coal (C).

Core 8 @ 8637.2'

Fauna. Unfossiliferous. Pyrite (F), Coal (F).

Core 8 @ 8641.7'

Fauna. Unfossiliferous. Pyrite (F), Coal (C).

Core 8 @ 8645.3'

Fauna. Unfossiliferous. Pyrite (C), Coal (C).

Core 8 @ 8646.7'

Fauna. Unfossiliferous. Pyrite (F), Coal (C).

Core 8 @ 8649.5'

Fauna. Unfossiliferous.

Core 8 @ 8653.4'

Fauna. Haplophragmoides sp.? (reworked?), Pyrite (C), Coal (A).

Core 8 @ 8654.1'

Fauna. Unfossiliferous. Pyrite (C), Coal (F).

Core 8 @ 8655.8'

Fauna. Unfossiliferous. Pyrite (R).

Core 9 @ 9255.4'

Fauna. Unfossiliferous. Pyrite (R), Coal (R).

Core 9 @ 9257.6'

Fauna. Unfossiliferous. Pyrite (R), Coal (F).

Core 9 @ 9262.0'

Fauna. Unfossiliferous. Pyrite (R), Coal (R).

Core 9 @ 9264.1'

Fauna. Unfossiliferous. Pyrite (C), Coal (F).

Core 10 @ 9945.6'

Fauna. Cribrononion aff. roemeri (R), Elphidium sp. (R), Elphidiella hannai (R).

Core 10 @ 9948.8'

Fauna. Unfossiliferous.

Core 10 @ 9949.5'

Fauna. Unfossiliferous. Coal (R).

Core 10 @ 9952.0'

Fauna. Unfossiliferous.

Core 10 @ 9954.3'

Fauna. Cribrononion aff. roemeri (V), Shells (R).

Core 10 @ 9956.6'

Fauna. Elphidium sp. (V), Elphidiella hannai (V), Pyrite (R).

Core 10 @ 9962.3'

Fauna. Cribrononion aff. roemeri (V).

Core 10 @ 9963.8'

Fauna. Unfossiliferous.

Core 10 @ 9965.8'

Fauna. Barren of Foraminifera. Shells (R).

Core 10 @ 9969.3'

Fauna. Cribrononion aff. roemeri (V).

Core 10 @ 9971.5'

Fauna. Cassidulina cf. crassipunctata (V), Cribrononion aff. roemeri (V).

Core 10 @ 9974.4'

Fauna. Barren of Foraminifera. Shells (R), Pyrite (R), Coal (R).

Core 10 @ 9976.8'

Fauna. Barren of Foraminifera. Shells (F).

Core 10 @ 9976.9'

Fauna. Barren of Foraminifera. Shells (F).

Core 10 @ 9978.1'

Fauna. Elphidiella hannai (V).

Core 10 @ 9981.3'

Fauna. Unfossiliferous

Core 10 @ 9982.2'

Fauna. Cribrononion aff. roemeri (R), Haplophragmoides sp. (V), Fish remains (V), Shells (R), Pyrite (F).

Core 10 @ 9983.6'

Fauna. Barren of Foraminifera. Echinoids (?), Pyrite (R).

Core 11 @ 10,326.0'

Fauna. Barren of Foraminifera. Shells (C).

Core 11 @ 10,327.4'

Fauna. Barren of Foraminifera. Shells (F), Coal (R).

Core 11 @ 10,328.9'

Fauna. Elphidium sp. (R), Elphidiella hannai (R), Ostracods (V), Shells (C).

Core 11 @ 10,330.3'

Fauna. Barren of Foraminifera. Ostracods (V), Shells (A).

Core 11 @ 10,334.7'

Fauna. Barren of Foraminifera. Shells (C).

Core 12 @ 10,731.2'

Fauna. Unfossiliferous. Coal (A).

Core 12 @ 10,734.0'

Fauna. Unfossiliferous. Coal (R).

Core 12 @ 10.735.8'

Fauna. Unfossiliferous.

Core 12 @ 10,737.0'

Fauna. Unfossiliferous. Coal (C).

Core 12 @ 10,738.9'

Fauna. Unfossiliferous. Coal (C).

Core 12 @ 10,739.5'

Fauna. Unfossiliferous. Coal (C).

Core 13 @ 11,085.0'

Fauna. Unfossiliferous.

Core 13 @ 11,089.4'

Fauna. Unfossiliferous.

Core 13 @ 11,093.7'

Fauna. Unfossiliferous. Pyrite (R).

Core 13 @ 11,098.1'

Fauna. Unfossiliferous. Coal (F).

Core 13 @ 11,098.5'

Fauna. Unfossiliferous. Coal (R).

Core 13 @ 11,100.7'

Fauna. Unfossiliferous. Pyrite (R), Coal (R).

Core 13 @ 11,102.4'

Fauna. Unfossiliferous. Coal (C).

Core 13 @ 11,103.4'

Fauna. Unfossiliferous. Coal (C).

Core 13 @ 11,109.4'

Fauna. Unfossiliferous.

Core 14 @ 12,249.0'

Fauna. Unfossiliferous. Coal (F).

Core 14 @ 12,251.1'

Fauna. Unfossiliferous. Coal (C).

Core 14 @ 12,253.1'

Fauna. Barren of Foraminifera. Shells (R).

Core 14 @ 12,255.8'

Fauna. Unfossiliferous.

Core 14 @ 12,259.3'

Fauna. Unfossiliferous. Coal (F).

Core 14 @ 12,260.8'

Fauna. Unfossiliferous. Coal (A).

Core 14 @ 12,262.3'

Fauna. Unfossiliferous. Coal (A).

Core 14 @ 12,262.6'

Fauna. Unfossiliferous. Coal (R).

Core 14 @ 12,264.3'

Fauna. Unfossiliferous. Coal (R).

Core 14 @ 12,265.1'

Fauna. Unfossiliferous. Coal (R).

Core 14 @ 12,268.4'

Fauna. Unfossiliferous. Coal (F).

Core 14 @ 12,269.4'

Fauna. Unfossiliferous. Coal (A).

Core 14 @ 12,269.7'

Fauna. Unfossiliferous. Coal (R).

Core 15 @ 12,630.4'

Fauna. Unfossiliferous. Coal (R).

Core 15 @ 12,632.1'

Fauna. Unfossiliferous.

Core 15 @ 12,633.2'

Fauna. Unfossiliferous. Coal (R).

Core 15 @ 12,635.3'

Fauna. Unfossiliferous. Coal (C).

Core 15 @ 12,637.5'

Fauna. Unfossiliferous.

Core 16 @ 14,165.7'

Fauna. Unfossiliferous. Coal (R).

Core 16 @ 14,167.9'

Fauna. Unfossiliferous. Coal (R).

Core 16 @ 14,169.1'

Fauna. Unfossiliferous.

Core 16 @ 14,177'

Fauna. Unfossiliferous. Coal (R).

Core 16 @ 14,179.7'

Fauna. Unfossiliferous. Coal (F).

Core 16 @ 14,183.4'

Fauna. Unfossiliferous. Coal (R).

Core 17 @ 15,347.7'

Fauna. Unfossiliferous.

Core 17 @ 15,349.6'

Fauna. Unfossiliferous. Coal (R).

Core 17 @ 15,349.9'

Fauna. Unfossiliferous. Coal (R).

Core 17 @ 15,354.5'

Fauna. Unfossiliferous. Coal (R).

Core 17 @ 15,358.8'

Fauna. Unfossiliferous. Coal (R).

Core 17 @ 15,364.9'

Fauna. Unfossiliferous.

Core 17 @ 15,366.1'

Fauna. Unfossiliferous.

Core 17 @ 15,367.1'

Fauna. Unfossiliferous.

Core 17 @ 15,368.4'

Fauna. Unfossiliferous.

Core 18 @ 16,066.8'

Fauna. Unfossiliferous.

Core 18 @ 16,009.2'

Fauna. Unfossiliferous.

Core 18 @ 16,011.9'

Fauna. Unfossiliferous.

Core 18 @ 16,017.5'

Fauna. Unfossiliferous.

Core 18 @ 16,020.7'

Fauna. Unfossiliferous. Coal (R).

Core 18 @ 16,023.0'

Fauna. Unfossiliferous. Coal (R).

Core 18 @ 16,025.3'

Fauna. Unfossiliferous. Coal (R).

Core 18 @ 16,026.9'

Fauna. Unfossiliferous. Coal (R).

Core 18 @ 16,029.0'

Fauna. Unfossiliferous.

Core 19 @ 16,701.2'

Fauna. Unfossiliferous.

Core 19 @ 16,703.7'

Fauna. Unfossiliferous.

Core 19 @ 16,705.2'

Fauna. Unfossiliferous. Coal (R).

Core 19 @ 16,707.5'

Fauna. Unfossiliferous. Coal (R).

Core 19 @ 16,714.6'

Fauna. Unfossiliferous.

Core 19 @ 16,716.2'

Fauna. Unfossiliferous.

Core 19 @ 16,717.9'

Fauna. Unfossiliferous. Coal (R).

Core 19 @ 16,719.6'

Fauna. Unfossiliferous. Glauconite? (A).